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User's Guide for SFTRAN/360

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USER'S GUIDE FOR SFTRAN/360

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SUMMARY

Extensions and improvements have been made to SFTRAN, a structured-programming language. This improved language has been implemented as a precompiler that translates from SFTRAN to FORTRAN and has been available to users of the Lewis Research Center's IBM 360/67 Time-Sharing System for the past year. This report describes the SFTRAN language and its use.

Time-Sharing System (TSS) command procedures have been implemented that eliminate the complications of dealing with extra files and processing steps which the use of a precompiler would otherwise require. These command procedures are described and their use is illustrated by examples.

INTRODUCTION

In recent years, two new programming concepts have received a good deal of attention in the literature. The first of these may be loosely termed "GO-TO-less programming," although a more appropriate description might be "avoidance of numbered statements." When this concept is employed, program flow is controlled by constructs, or structures, that imply a certain flow-chart function; the name given each construct is selected to be suggestive of its function. A principal benefit of GO-TO-less programming is that the resulting code is easier to read, both because the structure names are more meaningful than numbers and also because the reader's eye is not forced to leap around on the page or from one page to another.

The second concept involves what has been referred to as "stepwise refinement," the process of successively refining one's description of the solution method in terms of ever more primitive components or processes. At each level of refinement, only enough detail is presented to make the method clear. Anything of a complicated nature is merely referred to, with its precise definition postponed until later. Sometimes called top-down programming, this technique is another that results in an easier-to-read code. Only a few ideas need be kept in mind at each level of description; and the big, important ones can be put first, at the top, where they belong.

The combination of these two principles, GO-TO-less programming and stepwise refinement, results in what we will denote as "structured programming." The combined technique has more to offer, however, than merely good readability. It also provides a natural sequence of steps to be taken in the programming process: it replaces much of the <u>art</u> of programming with a methodology that is easy for the novice to learn and very efficient in the hands of the experienced. Also, a high degree of program modularity is obtained, which means that the code produced can easily be changed, extended, or adapted for other uses.

This report concerns a new implementation of the programming language SFTRAN, which was created by John T. Flynn[1] for the specific purpose of providing a language suitable for structured programming. Flynn's implementation of his SFTRAN language was a precompiler that translated from SFTRAN to FORTRAN. This permitted a great degree of simplification in the precompiler program; it only had to recognize the few special structures that control program flow. Also, by translating to FORTRAN, the benefits of program portability were automatically obtained.

Our work retains all of Flynn's original structures. The new SFTRAN precompiler differs from Flynn's in that it has been given additional language features, had some operating limitations removed, and has been designed to run more efficiently. This report describes the SFTRAN language and its use, as newly implemented.

Our effort, however, goes beyond refinement of an existing precompiler. We extend the concepts of modularity and top-down development to the area of task management and provide a set of command-level procedures for this purpose. Thus, the programmer is able to select one of several jobs, and one of several parts of that job, and to invoke one of several operations to be performed on that part. This can all be done by means of simple, brief statements designed expressly for the purpose. The programmer is thus freed of concern for bothersome details

[1]SFTRAN User Guide, JPL Interoffice Computing Memorandum 337 (Section 914), July 31, 1973.

of an operational nature and can instead concentrate his attention on those areas where his skill and effort are of maximum benefit. These task-management procedures, as implemented on the Lewis Research Center's TSS/360 computer system, are described in this report and examples of their use are included.

SFTRAN LANGUAGE

In brief, SFTRAN (Structured FORTRAN) is a programming language with the following features:

(1) It eliminates the burden of dealing with statement numbers. Program sections are referred to by name, not number.

(2) It allows and even encourages the grouping of instructions into small, natural units within a program or subprogram. These units can be given unique, descriptive names and are displayed in listings in a manner that makes their internal structure immediately apparent to the eye.

(3) It looks very much like ordinary FORTRAN, except for the manner in which branching and looping are handled.

The SFTRAN language is implemented by a precompiler that generates FORTRAN source code from SFTRAN source code. SFTRAN programs can therefore be considered machine independent to the same degree that their FORTRAN translations are machine independent.

The basic structures by means of which SFTRAN avoids the GO-TO or implied GO-TO statements of FORTRAN are the following:

(1) DO-PROCEDURE

(2) IF-THEN

(3) IF-THEN-ELSE

(4) DO-CASE

(5) DO-FOR

(6) DO-UNTIL

(7) DO-WHILE

(8) DO-WITH

The first structure refers to the PROCEDURE, a group of statements of any kind to which a unique name is given. (This name may and should be descriptive, of arbitrary length, with embedded blanks, special symbols, etc., if desired, and is the only means by which the group of statements may be invoked. The PROCEDURE thus operates very much like a baby subroutine within the program body, except that it can refer to any of the variables of the program.) The remaining seven structures provide commonly required types of program control, in which some sort of decisionmaking is performed.

One feature of the SFTRAN precompiler is the option to automatically assign statement numbers to normal SFTRAN output, flagging the various SFTRAN statements. Also, statement numbers that were supplied by the programmer in order to flag normal FORTRAN statements can be stripped off by the precompiler or left intact, as desired. (These statement numbers make it possible to do debugging directly from the SFTRAN code; the FORTRAN code produced by the precompiler is unsuitable for this, because it is hard to read.) Later on, when the programs are in good shape and clean text is desired, the SFTRAN precompiler can be invoked again, with these options reversed, to produce the final listings.

Programming in SFTRAN

Any group of statements and structures, providing it has only one entrance and one exit, can be designated as a single structural entity. This is accomplished in SFTRAN by means of the PROCEDURE declaration, which assigns a unique, descriptive name to the entity. At any point or points within the program, this entity can be invoked and executed by using the DO-PROCEDURE statement. The process of creating arbitrarily complex code, therefore, becomes one of organizing an appropriate assembly of concepts whose functions are indicated by their names but whose precise definition is deferred until the necessary level of detail is reached.

In those regions of a program where the flow of commands is not purely sequential, some sort of transfer is required. The transfer may be lateral, as when one of several alternatives must be selected and performed; or it may be backward, as when a block of instructions must be repeated a number of times. These cases are termed branching and looping, respectively.

The simplest form of branching involves only one block of instructions and the decision whether or not to perform it. In SFTRAN this is accomplished by means of the structure IF-THEN. When there are two alternatives, the modification IF-THEN-ELSE may be used. For more than two alternatives, a different form of structure, the DO-CASE, is available.

The simplest form of looping involves repetition of a block of instructions a certain number of times while an index is incremented. In SFTRAN this is accomplished by means of the structure DO-FOR. In more general cases the block must be repeated until a certain condition is attained or while a certain condition holds; these are implemented by the DO-UNTIL and the DO-WHILE structures, respectively. Still more general cases are treated with the DO-WITH structure, in which the condition test (either UNTIL or WHILE) may be placed anywhere within the block to be repeated.

Once the branching and looping structures have been defined, any program, no matter how complex, can be reduced to a set of simple structures each of which has only one entrance and one exit. As such, the structures are comparable to the simple statements forming sequential code.

Basic Structures

Each SFTRAN structure is delimited by a keyword statement that marks its beginning and an END statement that marks its completion; other keyword statements may occur between these two. The keyword statements and the END statement form the skeleton of the structure.

The remaining statements comprise the body of the structure and may be chosen freely by the programmer. For clarity, the body of a structure is indented in the output listing (but <u>not</u> the source) relative to the skeleton of that structure. (This principle continues to hold even when one structure forms part of the body of another structure.)

<u>DO-PROCEDURE</u>. - Any set of sequential statements and structures, providing it has only one entrance and one exit, may be designated as a single structural entity called a PROCEDURE. Its beginning is indicated by a keyword PROCEDURE statement, and its finish by an END statement. The keyword statement also contains the name assigned to the PROCEDURE - a string of characters contained within parentheses. An example of such a structure is

```
PROCEDURE (VECTOR PRODUCT: A(I) = B(I) X C(I))
    A(1,I)=B(2,I)*C(3,I)-B(3,I)*C(2,I)
    A(2,I)=B(3,I)*C(1,I)-B(1,I)*C(3,I)
    A(3,I)=B(1,I)*C(2,I)-B(2,I)*C(1,I)
END
```

In this example the PROCEDURE name is chosen to be as descriptive as possible. The name may be any length; all characters including blanks are significant. But PROCEDURE names should not contain apostrophes or unmatched (left with right) parentheses.

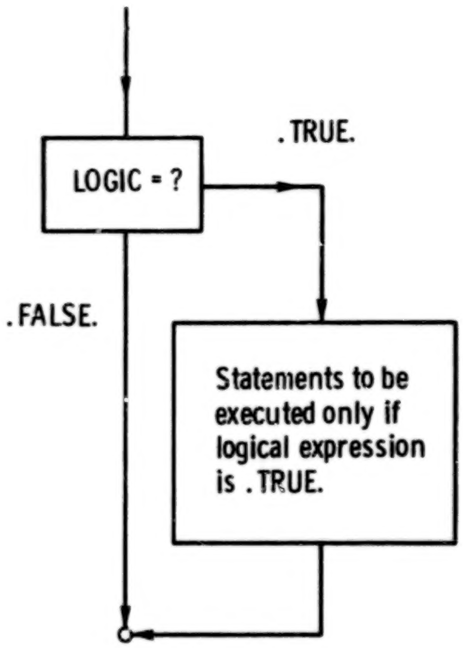
Loosely speaking, a PROCEDURE may be regarded as a subprogram, internal to the program or subprogram in which it appears. It is called from another point in the same program by a DO-PROCEDURE statement; for the preceding example,

```
         •
         •
         •
    DO (VECTOR PRODUCT: A(I) = B(I) X C(I) )
         •
         •
         •
```

There are a few simple rules governing the use of PROCEDURES. To begin with, the keyword PROCEDURE statement must stand alone; it cannot be defined within another structure. It must have no means of entry except for calls by DO-PROCEDUR statements; these DO statements are only effective within the program or subprogram in which the PROCEDURE is defined.

The name in a PROCEDURE call must be exactly the same as the name in the PROCEDURE definition. For this reason, a PROCEDURE name may appear in only one keyword PROCEDURE statement; it may appear more than once in DO-PROCEDUR calls, but it must appear at least once. Finally, although the body of a PROCEDURE may be made up of other SFTRAN statements and structures, including calls to other PROCEDURES, it may not call itself either directly or indirectly; PROCEDURES do not have recursive capability. The SFTRAN precompiler does not check this; it is the programmer's responsibility to ensure that recursive calls will not occur.

IF-THEN. - The simplest form of branching is the IF-THEN structure, whose flow diagram is



.TRUE.
LOGIC = ?
.FALSE.
Statements to be executed only if logical expression is .TRUE.

An example of IF-THEN coding is

```
         •
         •
         •
   IF (.NOT.FOUND) THEN
      DO (REPORT MISSING ITEM)
      STOP
   END
         •
         •
         •
```

(Of the two statements forming the body of the IF-THEN structure, the first is an SFTRAN-type statement and the second is a FORTRAN-type statement.) An abbreviation of this structure is possible whenever only one statement is contained in the conditional block. For example, instead of

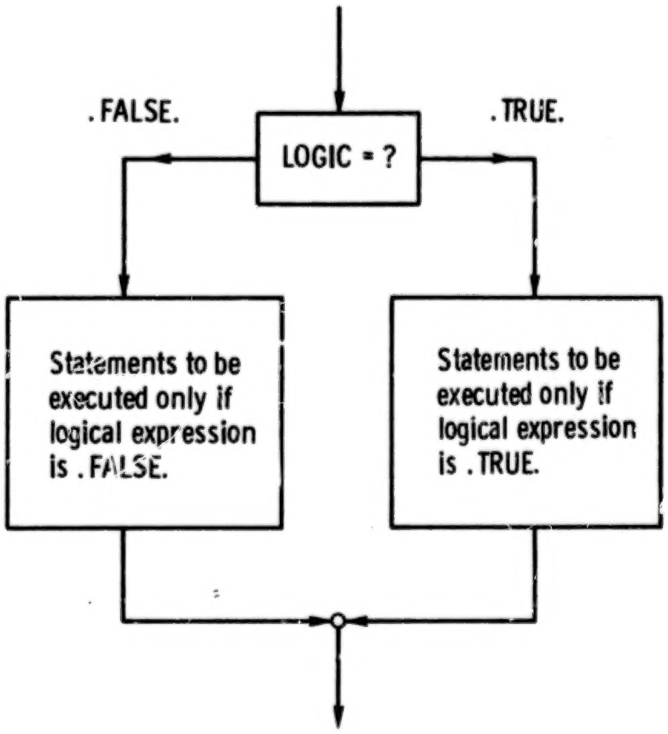
```
          •
          •
          •
    IF (.NOT.FCUND) THEN
       DO (REPORT MISSING ITEM)
    END
          •
          •
          •
```

the abbreviation

```
          •
          •
          •
    IF (.NCT.FCUND) DO (REPORT MISSING ITEM)
          •
          •
          •
```

may be used. Note that THEN and END are omitted in the abbreviated version, an exception to the general rule that every structure begins with a keyword and ends with an END statement.

IF-THEN-ELSE. - When branching involves two alternatives, the structure IF-THEN-ELSE may be used. Its flow diagram is



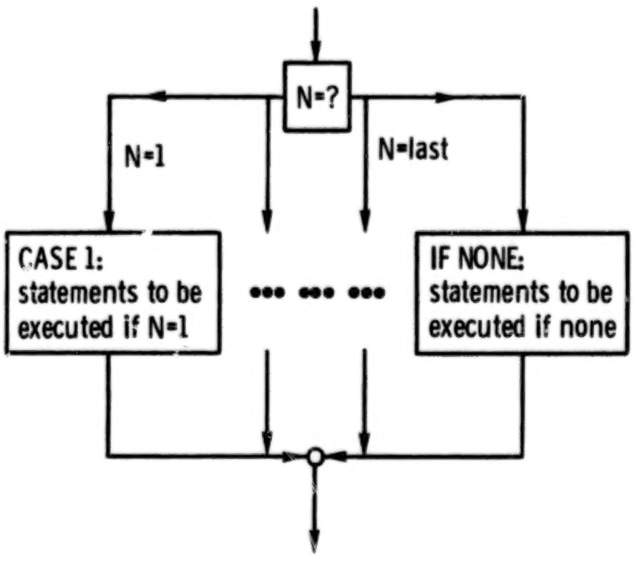
.FALSE.
LOGIC = ?
.TRUE.
Statements to be executed only if logical expression is .FALSE.
Statements to be executed only if logical expression is .TRUE.

An example of IF-THEN-ELSE coding is

```
         •
         •
         •
IF (I.EQ.J) THEN
   DO (I=J CASE)
   CALL SUB1(X,Y,Z)
ELSE
   DO (NORMAL CASE)
   CALL SUB2(X,Y,Z)
END
         •
         •
         •
```

The statements to be executed if LOGIC is .TRUE. come right after the IF-THEN keyword statement; the statements to be executed if LOGIC is .FALSE. come right after the ELSE keyword statement. In either case, program flow then passes to the first statement following the structure's END statement.

DO-CASE.- When branching involves more than two alternatives, the DO-CASE structure may be used. Here the alternative to be chosen is determined by examining an integer variable rather than a logical variable. The flow diagram of the DO-CASE structure is


N=?
N=1
N=last
CASE 1: statements to be executed if N=1
••• ••• •••
IF NONE: statements to be executed if none

An example of DO-CASE coding is

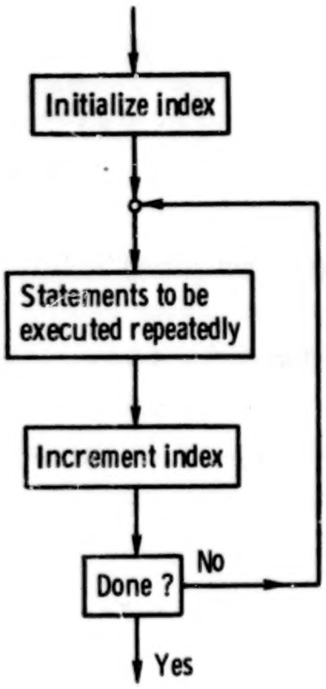
```
          •
          •
          •
DO CASE (ITYPE,3)
CASE 1
   POLY=A*X+B
CASE 2
   POLY=A*X**2+B*X+C
CASE 3
   DO (NOT LINEAR OR QUADRATIC)
IF NONE
   DO (REPORT TYPE ERROR)
END
          •
          •
          •
```

The case-choice and the case-limit appear in the keyword DO-CASE statement. The definitions of each possible case form the body of the structure, separated by keyword CASE N statements. As usual, an END statement marks the completion of the structure.

The case-choice must be a nonsubscripted integer variable; and the case-limit must be a positive, literal, integer constant. The number of keyword CASE N statements must be equal to the case-limit, and they must be given in sequential order, beginning with CASE 1. Each case definition follows its own keyword CASE N statement; even if a definition is null, containing no statements, the keyword CASE N is required.

If the case-choice is not within range of the number of cases defined (less than 1 or greater than the case-limit), control will pass to the next statement after the END of the DO-CASE structure unless an IF NONE contingency case is provided. If an IF NONE case is provided, it must follow the last case in the structure.

DO-FOR. - The simplest form of looping involves repetition of a block of instructions a certain number of times, while an index is incremented. This is accomplished by means of the DO-FOR structure, whose flow diagram is



An example of DO-FOR coding is

```
         •
         •
         •
    DO  FOR I=2,N,2
        X(I)=Y(I)+Z(I)
    END
         •
         •
         •
```

In this example, X(I) will be calculated for all even values of I from 2 to N; then control will pass to the next statement following the structure's END statement. Initialization, incrementing, and testing are implied by the structure and are <u>not</u> explicitly programmed.

The general form of the DO FOR statement is

```
DO FOR I=N1,N2,N3
```

where I is the index and N1, N2, and N3 are the initial, terminal, and increment parameters. The index of a DO-FOR must be an integer variable and may not be redefined within the body of the DO-FOR structure. The SFTRAN precompiler does not check this; it is the programmer's responsibility to ensure that such redefinitions do not occur.

The DO-FOR parameters determine the initial value, N1; the increment value, N3; and the number of times, (N2-N1)/N3+1, that the body of the DO-FOR structure will be executed. These parameters may be literal integer constants, integer variables, or integer expressions. For instance, a complicated example would be

```
DO FOR INDEX = 0, IFUNC(X)+J*K, -NUM
```

Variables appearing in N1, N2, or N3 may be changed during execution of the statements contained within the DO-FOR structure with no effect; only their values at the start are used to control indexing. If N3 is omitted, its value is assumed to be 1 (unless N1 and N2 are literal constants and the value of N1 is greater than that of N2, in which case N3 is assumed to be 1).

Recapitulating, the DO-FOR structure is executed as follows:

(1) The index is initialized to the value of N1.

(2) The values of N2 and N3 are saved.

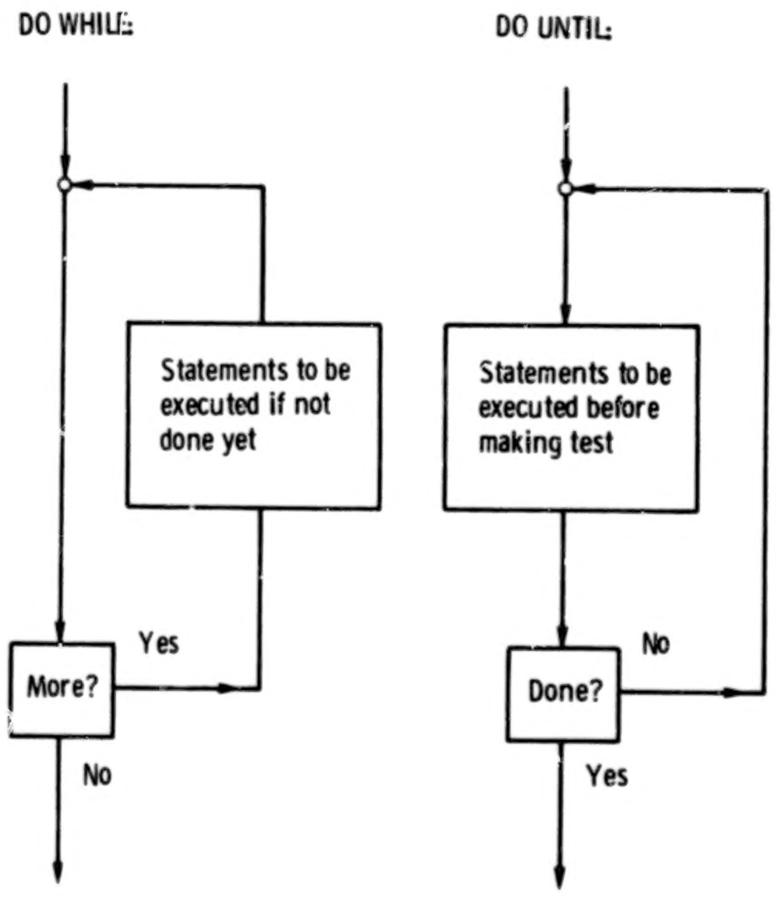
(3) The statements contained in the body of the DO-FOR structure are executed.

(4) The index is increased by the value of N3.

(5) If N3*(N2-I) is negative, the DO-FOR is completed. Otherwise, steps 3, 4, and 5 are repeated.

When a DO-FOR structure is completed normally (by step 5 above), the value of the index is not the same as it was during execution of the body of the structure (in step 3) the last time.

DO-WHILE and DO-UNTIL. - In more general cases of looping, the block of statements must be repeated until a certain condition is attained, or while a certain condition holds. In SFTRAN these are accomplished by means of the DO-UNTIL and DO-WHILE structures, respectively. Their flow diagrams are


DO WHILE:
Statements to be executed if not done yet
More?
Yes
No
DO UNTIL:
Statements to be executed before making test
Done?
No
Yes

An example of DO-WHILE coding is

```
         •
         •
         •
DO WHILE (N.GT.0)
   DO (PROCESS N-TH ITEM IN LIST)
   N=N-1
END
         •
         •
         •
```

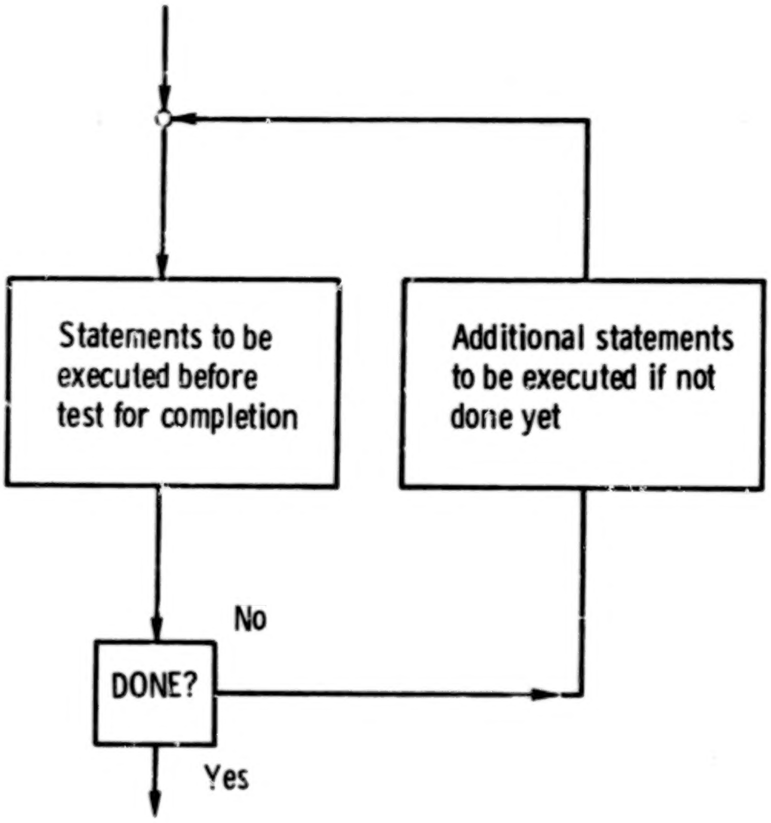
(In a DO-WHILE the logic test is made at the start, to determine if conditions for looping are allowed. Hence, if N should be 0 at the start, control will pass immediately to the statement following the structure's END statement.)

An example of DO-UNTIL coding is

```
         •
         •
         •
VALUE=GUESS
DO UNTIL (TERM.LE.SMALL)
   DO (CALCULATE HIGHER-ORDER TERM)
   VALUE=VALUE+TERM
END
         •
         •
         •
```

(In a DO-UNTIL the logic test is made at the end, to determine if looping is to continue. Hence, TERM, the first correction to GUESS, will be calculated and added <u>before</u> being examined to see whether it is SMALL enough to discontinue looping.) Note that it is quite possible to program an infinite loop, in which the completion test is never satisfied. The SFTRAN precompiler cannot check this. It is the programmer's responsibility to avoid infinite loops.

<u>DO-WITH</u>. - In more general cases of looping it is desirable to have the completion test take place other than at the start or the end of the loop. For these cases the DO-WITH structure is available, whose flow diagram is


Statements to be executed before test for completion
Additional statements to be executed if not done yet
No
DONE?
Yes

An example of DO-WITH coding is

```
       •
       •
       •
 ITEM=1
 DO WITH
    DO (CHECK FOR MATCH WITH STANDARD VALUE)
 UNTIL (MATCH.OR.ITEM.EQ.LAST)
    DO (PROCESS NON-MATCHING ITEM)
    ITEM=ITEM+1
 END
 IF (.NOT.MATCH) DO (REPORT MISSING ITEM)
       •
       •
       •
```

In this case, the DO-WITH completion test is indicated by the keyword UNTIL statement. A WHILE statement could also have been used. For the UNTIL test, a .TRUE. value signals completion of the looping. For the WHILE test, a .FALSE. value signals completion. In either case, one and only one WHILE/UNTIL statement may be used in the DO-WITH structure, but it may be placed anywhere within the body of the structure.

Additional Forms

The basic structures just defined are more than adequate to describe even the most complex program flow. But, because of its FORTRAN origin, SFTRAN has been given three additional forms: READ and WRITE parameters, EXITS from a DO-FOR, and INCLUDE and DEFINITION.

READ and WRITE parameters. - READ and WRITE statements in SFTRAN may contain END and/or ERR parameters, just as they do in FORTRAN. In SFTRAN, however, these parameters set logical variables instead of causing control transfers. For example, the statement

```
READ (UNIT,FMT,DONE=END) LIST
```

will read into LIST from UNIT according to the format specified in FMT. If an end-of-file is encountered, the logical variable DONE will be set to .TRUE.; otherwise, DONE will be set to .FALSE. The following example is part of a main program that makes use of this feature:

```
         •
         •
         •
DO WITH
   READ (5,100,DONE=END) DATA
UNTIL (DONE)
   DO (PROCESS ALL DATA IN THIS GROUP)
   DO (PRINT RESULTS OF PROCESSING)
END
STOP
         •
         •
         •
```

To illustrate the use of the ERR parameter, suppose that the READ statement in this example is replaced by

```
READ (5,100,DONE=END,SCREWY=ERR) DATA
IF (SCREWY) THEN
   KIND=4
   DO (ERROR HANDLING ROUTINE)
END
```

The program will operate just as before, unless an error is encountered at READ time. In that event, SCREWY will be set to .TRUE., and then the procedure ERROR HANDLING ROUTINE will be invoked for KIND=4. (If no READ error is encountered, SCREWY will be set to .FALSE.)

EXITS from a DO-FOR. - It has been stated that every SFTRAN structure has only one entrance and one exit. Like most generalities, this admits of an exception: the EXIT statement. The EXIT statement, which may be used only in connection with a DO-FOR structure, has been added to give that structure the feature of having a completion test *within* the body of the structure. In this respect it is similar to the UNTIL or WHILE statements of the DO-WITH structure. For instance, the statement

```
IF (EQUAL) EXIT
```

in a DO-FOR structure is roughly analogous to the statement

```
UNTIL (EQUAL)
```

in a DO-WITH structure. The EXIT statement, however, possesses a feature that makes it much more powerful than UNTIL/WHILE statements; it can optionally include the name of a DO-FOR structure index, in parentheses, to cause EXIT from that DO-FOR structure. In this respect, it furnishes a means of unconditional transfer out of a *nest* of structures. Consider, for example, the following SFTRAN code:

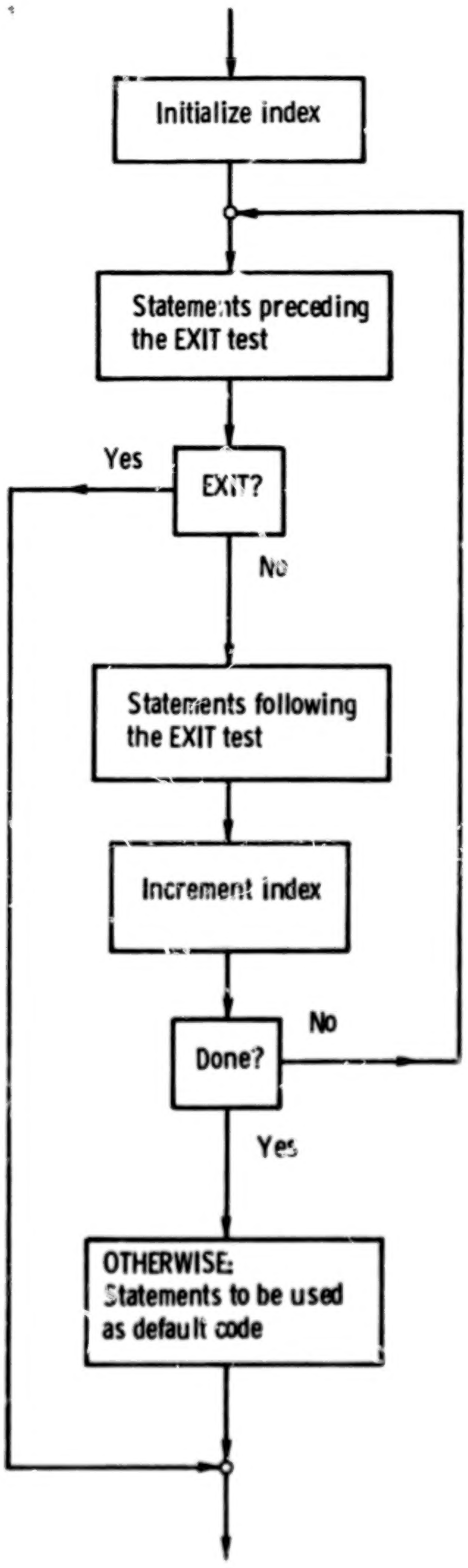
```
          .
          .
          .
     DO FOR ITEM=1,LAST
        DO (GET DATA ITEM AND ALL 5 STANDARD VALUES)
        DO FOR KIND=1,5
           DO (CHECK FOR MATCH WITH THIS KIND OF STANDARD)
           IF (MATCH) THEN
              DO (PROCESS MATCHING CASE)
        <-----EXIT (KIND)
           END
           DO (PROCESS NON-MATCHING CASE)
        END
     END
          .
          .
          .
```

When a MATCH is found, it is processed and then control is transferred out of the IF-THEN structure to the first statement following the END statement of the DO-FOR structure with index name KIND. For clarity, this is indicated in the output listing (but not the source) by a left-going arrow. (The alternative structure

```
        IF (MATCH) THEN
           DO (PROCESS MATCHING CASE)
     <-----EXIT (KIND)
        ELSE
           DO (PROCESS NON-MATCHING CASE)
        END
```

is nominally correct, but its ELSE block is clearly unnecessary. Consequently, this form is not allowed, and the precompiler is programmed to regard it as an error See the section Comments.)

In any event, it is obvious that the EXIT statement will be associated with a test of some sort. The question then arises, What about the possibility that no EXIT has occurred by the time the loop is finished? Without a special provision, control would pass to the next statement following the appropriate END statement - just as if an EXIT had occurred. To handle this situation, SFTRAN provides the keyword OTHERWISE (again, to be used only in the DO-FOR structure). The flow diagram for a DO-FOR with an EXIT and an OTHERWISE is


Initialize index
Statements preceding the EXIT test
Yes
EXIT?
No
Statements following the EXIT test
Increment index
No
Done?
Yes
OTHERWISE:
Statements to be used as default code

An example of DO-FOR coding with an EXIT and an OTHERWISE is

```
         •
         •
         •
DO FOR KIND=1,5
   DO (CHECK FOR MATCH WITH THIS KIND OF STANDARD)
<--IF (MATCH) EXIT
   DO (PROCESS NON-MATCHING CASE)
OTHERWISE
   DO (REPORT NO MATCH FOUND)
END
         •
         •
         •
```

In this case, the procedure REPORT NO MATCH FOUND will be executed if the item matches none of the standards; but normally a match will be found, and control will be transferred out of the DO-FOR structure. (The optional, abbreviated version of EXIT has been used that omits THEN and END, and the index name KIND has been omitted because exit is from the immediate structure.)

INCLUDE and DEFINITION. - FORTRAN compilers require that certain classes of statements appear in the program before certain other classes of statements. (For example, function definition statements must appear before any executable statements.) In SFTRAN, the INCLUDE statement provides a way to specify where a block of statements, defined elsewhere in a DEFINITION structure, is to be located in the FORTRAN output from the precompiler.

The INCLUDE statement allows the programmer to indicate the presence of a group of statements without spelling them out. Thus, he can express main ideas at the top of the program without the clutter of detail, best left until later. As with DO-PROCEDURE statements and PROCEDURE blocks, INCLUDE statements are related to their corresponding DEFINITION blocks by a unique (hopefully descriptive) name. An example of the INCLUDE statement is

```
            •
            •
            •
      INCLUDE (TYPE STATEMENTS, ETC.)

C.....MAIN FLOW:
      DO (INITIALIZE PROGRAM)
      DO WITH
         READ (5,INPUT,DONE=END)
      UNTIL (DONE)
         DO (FIRST-ORDER CALCULATION)
           •
           •
           •
```

Then, at another point in the program, perhaps at the bottom, would be

```
           •
           •
           •
      DEFINITION (TYPE STATEMENTS, ETC.)
         LOGICAL DONE
         REAL X(25),Y(25)
         NAMELIST /INPUT/ X,Y,NXY
      END
           •
           •
           •
```

In the FORTRAN output from the precompiler, the statements LOGICAL, REAL, and NAMELIST will appear in place of the INCLUDE statement, and the DEFINITION and END statements will not appear.

There are a few rules governing the use of INCLUDE and DEFINITION statements. DEFINITION statements must stand alone; they cannot be contained in any other structure. INCLUDE statements must not be contained in DEFINITION blocks (they cannot be nested). The names of INCLUDE and DEFINITION statements should not contain apostrophes or unmatched (left with right) parentheses. And names must match exactly: each name must appear <u>only twice</u>, once in an INCLUDE statement and once in a DEFINITION statement.

Comments

As noted, the EXIT statement requires special attention because it can cause unconditional transfer out of a structure (other than at its normal END). There are also two common, allowable FORTRAN statements that possess this characteristic: RETURN and STOP. The rules governing the use of EXIT, RETURN, and STOP within structures are as follows:

(1) They may be used in IF-statements.

(2) They may be used alone as the last statement in an IF-THEN structure, an OTHERWISE block of a DO-FOR structure, a CASE or IF NONE block of a DO-CASE structure.

(3) No other use within structures is allowed.

Occasionally, errors in form or spelling may cause the SFTRAN precompiler to pass over statements (thinking them to be FORTRAN) when the programmer had intended them as SFTRAN. The FORTRAN compiler will, of course, complain about these, and the programmer should then be able to determine what caused the precompiler to ignore the statements in the first place.

Finally, SFTRAN does not permit free-form coding. Columns 1 to 5 are reserved for statement numbers (except in comment lines) and column 6 is reserved for a continuation character. (Hyphens should not be used to indicate that a statement is continued on the following line.) Statement scanning begins in column 7; any initial blanks will be regarded as relative indenting and will be preserved by the precompiler. The SFTRAN precompiler uses only the first 72 columns of each line. (However, this line-length standard may be altered by the user at precompilation time, as described in the following section.)

TASK MANAGEMENT SYSTEM

For the following discussion, it will be helpful if the reader has had an introduction to the IBM 360/67 Time-Sharing System (TSS) and also its Command System User's Guide (CSUG), reference 1. The command system procedures and file organization described here supplement the commands that are a part of TSS; they do not replace them. The task-management commands are summarized in appendix A. These new commands provide the following features:

(1) They greatly simplify the management of several jobs under one USERID and at the same time make it easy for several programmers to work as a team on one job.

(2) They provide all of the library functions essential in multijob, multiprogrammer environments without the need to assign this work to an individual.

(3) They make full use of, and are fully compatible with, IBM's TSS facilities. Only standard features of task and data management are required.

(4) They provide features that are equally available in either conversational or batch modes.

It is recommended that partitioned data-set libraries be used for source code, for object code, and for listings. The command procedures, which assume this organization, are provided to simplify task management.

To illustrate the method, suppose that the assignment is to analyze sonic booms and that the programmer has written a main program (MAIN) and two subroutines (INPUT and OUTPUT), all in SFTRAN.

The first step is to put MAIN, INPUT, and OUTPUT into the source library, a VP data set called (say) SOURCE.SONIC.BOOM (or any other name the programmer likes). That is, SOURCE.SONIC.BOOM is created with members MAIN, INPUT, and OUTPUT. This organization will keep name conflicts to a minimum and also provides an excellent filing scheme.

The next step is to make object members corresponding to MAIN, INPUT, and OUTPUT. Suppose the programmer begins with MAIN, invoking the SFTRAN precompiler. This would produce two new data sets, one for further processing and one for listing purposes.

The first data set, called SOURCE.MAIN$, is the FORTRAN version of MAIN and is ready for processing by the FORTRAN compiler. After compilation, the resulting object code will be put into the object library, a VP data set called OBJECT.SONIC. BOOM, as member MAIN$. The $ sign is used to avoid conflicts that might arise if an entry-point name is the same as the member name.

The second data set produced by the precompiler has been put into the listing library, which is a VP data set called LISTINGS.SONIC.BOOM, as member MAIN. The latter is an SFTRAN version of MAIN that has been indented to reveal how the structures are nested. (In SFTRAN, statement text is assumed to begin in column 7, except for comment statements. If leading blanks do occur beginning in column 7, these will be preserved by the precompiler as additional indentation, relative to that showing structure nesting.)

Occasionally, the need arises to save a FORTRAN source member for a particular job. In the present case, for example, a Bessel function subroutine like BESORD might be required and could be stored in SOURCE.SONIC.BOOM as member BESORD$. Again, the $ sign on BESORD$ would identify it as a FORTRAN-language element.

Command Procedures

Twelve command procedures have been provided to assist in creating and managing the SFTRAN job libraries:

```
JOB              STORE            LISTINGS         PRINTLIB
SFTRAN           EDITLIB          $STAMP           ERASELIB
FORTRAN          REDITLIB         $INCLUDE         UNSTORE
```

(They have been grouped according to their functions: processing, editing, listing, and miscellaneous.)

Task selection is accomplished by command procedure JOB; object members are created either from SFTRAN-language source-library members, by using command procedure SFTRAN, or from FORTRAN-language source-library members, by using command procedure FORTRAN. Individual VI data sets may be stored in the source library by using the command procedure STORE; source-library members may be created or edited with command procedures EDITLIB or REDITLIB. Source-code listings are obtained by command procedure LISTINGS; $STAMP (used only by command procedures SFTRAN and FORTRAN) puts an identifying header on source listings; $INCLUDE (used only by command procedure LISTINGS) collects several source listings into one data set for batch printing. Batch prints of original, unprocessed source-library members may be obtained by command procedure PRINTLIB; when a given program is no longer needed, source, object, and listing members are removed from the libraries by command procedure ERASELIB; a VI data set copy of any source-library member can be produced with command procedure UNSTORE. In this section, examples are given to show how these commands can be used. A summary of the commands and their operands is given in appendix A.

Job. - At the start of each task creation and management session, one normally issues a command such as

```
JOB SONIC.BOOM
```

This sets up DDEF's and DEFAULT's so that subsequent commands refer to the correct VP data sets. (Later, if the command JOB? were entered, the response would be SONIC.BOOM.) These data sets will be called SOURCE.NAME, OBJECT.NAME, and LISTINGS.NAME, where NAME is the first parameter in the JOB command. (If a different nomenclature is desired, such as NAME.SRC, NAME.OBJ, and NAME.LST, the JOB command procedure should be suitably modified.) At the close of a session, the JOB command may be issued without parameters to release the DDEF's and to eliminate the DEFAULT values. This will return the user profile to what it was just before the JOB command was first issued.

In addition to defining the various libraries, the JOB command may also be used to establish standard operating procedures. For example, one might enter

```
    JOB SONIC.BCOM,  NUMBER=Y,STRIP=Y,OFFLINE=Y
```

These additional operands require that (unless otherwise specified, when command procedure SFTRAN is called),

(1) The various elements of SFTRAN <u>structures</u> be numbered on all SFTRAN listings
(2) Programmer-supplied statement numbers be <u>stripped</u> from all SFTRAN listings
(3) Error messages and their line numbers go <u>offline</u> to the SFTRAN listings, not to the terminal

(Normally, the internally generated statement numbers are not shown, programmer-supplied statement numbers are not stripped, and error messages appear at the terminal.)

Another version of the JOB command might be

```
    JOB SONIC.BOOM, FORTRAN=N,LISTING=Y,LINES=Y
```

These additional operands require that (unless otherwise specified, when command procedure SFTRAN or command procedure FORTRAN is called),

(1) FORTRAN source data sets created by the precompiler are <u>not</u> to be compiled
(2) A listing of indented SFTRAN output (or a FORTRAN listing in the event that command procedure FORTRAN is used) <u>is</u> to be printed for each member processed by the SFTRAN command procedure

(3) Line numbers are to be included in listings
(Normally, the FORTRAN compiler will be called if no precompiler errors are detected, SFTRAN output listings are not printed since they may not be the final version desired, and listings are normally printed without line numbers.)

Any combination of these operands may be used when JOB is invoked. The choices specified then hold for all subsequent processing during that terminal session, unless revoked by another JOB command (or temporarily overridden by a particular SFTRAN or FORTRAN call).

SFTRAN. - The command procedure SFTRAN is used to process source members, written in SFTRAN, that are stored in a particular source library. First each member is precompiled, creating SFTRAN output for listing and a FORTRAN source data set; then (depending on defaults) the SFTRAN output is printed and the FORTRAN source data set is compiled.

Suppose, for example, that the JOB name is SONIC.BOOM, the JOB command has been issued previously, and there are two members to process. These are stored in the source library as members MAIN and SEARCH. Then, to begin processing, enter

```
    SFTRAN MAIN,SEARCH
```

If no precompiler errors or compiler errors are detected, an underscore will eventually be received at the terminal. When it is, the following data sets will have been created:

(1) LISTINGS.SONIC.BOOM(MAIN)
(2) LISTINGS.SONIC.BOOM(SEARCH)
(3) SOURCE.MAIN$
(4) SOURCE.SEARCH$

The first two are indented SFTRAN output produced by the precompiler and may be printed using LISTINGS. The second two are FORTRAN source data sets (in temporary storage, with DDEF's released) used by the FORTRAN compiler to create object members MAIN$ and SEARCH$ in the object library.

If the precompiler detects errors, messages will appear at the terminal (unless OFFLINE=Y is specified when the JOB or SFTRAN command is issued) and the FORTRAN compiler will not be invoked. If the FORTRAN compiler detects errors, messages will appear at the terminal inviting line corrections. It is possible to enter corrections at this time, but it is better to avoid this (default after the # prompt, enter N after MODIFICATIONS?) and to correct the SFTRAN code instead. Note that, after an attention-out of command procedure SFTRAN, it is possible (but not likely) that the default value of LIMEN will be left at X. This is undesirable, so check it out.

As was mentioned, the precompiler normally scans only the first 72 columns of each line. This number is determined by the value of the keyword operand $SFTRECL. For example, the command

```
    SFTRAN XLONG, $SFTRECL=100
```

will enable the precompiler to process XLONG, which may have lines of code extending out as far as column 100. (But this will reduce the allowable number of continuation lines from 19 to 13 and may cause some long lines to be truncated in indented listings.)

Other forms of the SFTRAN call are possible, such as

```
    SFTRAN MAIN,SEARCH, NUMBER=Y,STRIP=Y,OFFLINE=Y
```

or

```
    SFTRAN MAIN,SEARCH, LISTING=Y,FORTRAN=N
```

The keyword operands in these two examples have been discussed, and their use here is to override (temporarily) the choice made with the JOB command.

FORTRAN. - The command procedure FORTRAN is used to compile members, written in FORTRAN, that are stored in a particular source library. Such members may have already been precompiled and saved (unlikely), or they may be special programs not intended for the precompiler (e.g., obtained elsewhere in FORTRAN IV.)

Consider, for example, the FORTRAN subroutine BESORD. This would probably be stored in the source library as member BESORD$, with the $ suffix indicating that it is written in FORTRAN and is not suitable for the precompiler. (Actually, the precompiler would simply output each line of BESORD$ as it received it, without modification.) Then, assuming that the JOB command has been previously issued, one enters

```
FORTRAN BESORD$
```

After the underscore is received, the member BESORD$ will exist in the object library, and in LISTINGS.SONIC.BOOM for later listings if desired.

The command procedure FORTRAN also has the operand keywords LISTING and LINES, which may be used to override (temporarily) the choice made with the JOB command.

STORE. - The command procedure STORE is used to load individual VI data sets into a particular source library. These data sets may be read in from cards, obtained from another source library by means of command procedure UNSTORE, or copied or shared from another user. The only requirement is that each data set be cataloged in the form SOURCE.NAME, where NAME is a valid source-library member name.

Suppose, for example, that there is a VI source data set, written in SFTRAN, for subroutine SEARCH. Then, assuming that the dataset is cataloged as SOURCE.SEARCH (this would be done automatically by UNSTORE) and that the JOB command has been issued, enter

```
STORE SEARCH
```

The result is that the VI data set SOURCE.SEARCH is erased, (unless the command had been STORE SEARCH,ERASE=N) and the member SEARCH now exists in the source library. If a previous version of SEARCH had been stored, that version is replaced by the new one.

EDITLIB. - The command procedure EDITLIB is used to create or edit a member of a particular source library, using the TSS editor. Suppose the member name is, or is to be, SEARCH; then, assuming the JOB command has been issued, enter

```
EDITLIB SEARCH
```

The usual prompts and messages from the TSS editor will appear, and editing may be discontinued by entering END or _END, as appropriate.

REDITLIB. - The command procedure REDITLIB is used to create or edit a member of a particular source library, using the research editor (REDIT). Suppose the member name is, or is to be, SEARCH; then, assuming the JOB command has been issued, enter

```
    REDITLIB SEARCH
```

to begin editing of member SEARCH. (For convenience, REDITLIB uses the parameter $OPTIONS to set the initial state of REDIT. The default string furnished for $OPTIONS is 'TABSET 7; TRUNC 72; BRIEF N,F; VERIFY C,I,M,P' - you will be able to tab to column 7, lines longer that 72 characters will be truncated, and REDIT will not print line numbers or require a file name when the file command is issued, but it will furnish prompting clicks and informational and error messages and automatically print lines located or changed. If this mode is unfamiliar or seems awkward, the user may set his own default value for $OPTIONS.) When editing is completed, the command

```
    REKEY; FILE; PAUSE (or QUIT)
```

will return you to TSS.

LISTINGS. - The command procedure LISTINGS is used to obtain listings of indented SFTRAN code produced by the precompiler. It assumes that the member already exists in the listing library. (If this is not the case, perhaps because of an error in typing the member name, unintelligible messages will be issued. If this occurs, press the attention key and issue PAUSE or QUIT to leave REDIT.) Suppose that SFTRAN listings of MAIN and SEARCH are desired; then, assuming the JOB command has been issued, enter

```
    LISTINGS MAIN,SEARCH
```

This will create a VS data set, flagged for batch printing, named SONIC.BOOM. PROGRAMS (in temporary storage with DDEF released). This single data set will contain copies of both the MAIN and SEARCH modules, with identifying headings that will appear on each printed page; one print request will have been issued. As another example, the command

```
LISTINGS OUTPUT,BESORD$,LINES=Y
```

will produce a listing of the SFTRAN-language module OUTPUT and the FORTRAN-language module BESORD$, with line numbers. (Member OUTPUT in LISTINGS. SONIC.BOOM was created by command procedure SFTRAN; member BESORD$ was created by command procedure FORTRAN.)

Command procedure LISTINGS can also use, as an alternative operand, a list of member names that has been stored in the source library as member NAMELIST. For example, suppose the list

```
MAIN
SEARCH
OUTPUT
BESORD$
```

is stored in SOURCE.SONIC.BOOM(NAMELIST). Then, at the close of a session during which several program changes were made, the command

```
LISTINGS *ALL
```

could be used to obtain a fresh composite listing of these four modules, in the order given.

$\underline{\text{\$STAMP}}$. - The command procedure $STAMP is used only by command procedures SFTRAN and FORTRAN. Its function is to put identifying (paginating) headings on the members of the listing library at the time they are created.

$\underline{\text{\$INCLUDE}}$. - The command procedure $INCLUDE is used only by command procedure LISTINGS. Its function is to concatenate several members of the listing library data set into one data set for batch printing.

$\underline{\text{PRINTLIB}}$. - The command procedure PRINTLIB is used to obtain batch prints of source library members. Generally, these will be original (nonindented) SFTRAN codes, certain FORTRAN source codes that have been stored, or documentation describing the job and the programs. For example, assuming that the JOB command has been issued, enter

```
PRINTLIB MAIN,BESORD$,SYSDOC
```

to obtain batch prints of MAIN, BESORD$, and program documentation SYSDOC.

ERASELIB. - The command procedure ERASELIB is used to remove a member that is no longer wanted from the source, object, and listing libraries of a particular job. For example, assuming that the JOB command has been issued, enter

```
ERASELIB SEARCH,INPUT
```

to remove source members SEARCH and INPUT from the source library, object members SEARCH$ and INPUT$ from the object library, and listings SEARCH and INPUT from the listing library.

UNSTORE. - The command procedure UNSTORE is used to create individual VI data set copies, with the prefix SOURCE., of members of a particular source library. (Normally, it is used only by the other command procedures, but it will be found convenient should a source member from one job be needed by another job.) For instance, if the source library contains members SEARCH and BESORD$, and the JOB command has been issued, one could enter

```
UNSTORE SEARCH,BESORD$
```

to create the VI data sets SOURCE.SEARCH and SOURCE.BESORD$. (The original members are still in the source library. Also, the unstored copies are in temporary storage only.)

Comments Concerning Task Management

A few final comments about the command procedures may be useful. Most of them can be used recursively; that is, up to 10 member names may be entered, in addition to the keyword operands. Those that cannot are JOB (which takes no member name operand) and EDITLIB, REDITLIB, and $STAMP (for which recursion would be of doubtful value).

One of the advantages of source libraries is that naturally occurring names such as MAIN, INPUT, OUTPUT, SEARCH, etc., may be used for different jobs without conflict. There are two precautions that should be taken, however. The first is to avoid having a member name that is identical to the job name: a source library named SOURCE.FLOW, for instance, will eventually cause problems if it contains a member named FLOW. (If identical names are really desirable, the conflict may be avoided by suitably modifying command procedure JOB.)

The second precaution is to use member names containing not more than six characters. No difficulty arises if member names are identical to entry-point names, because the FORTRAN object members produced will have a $ sign suffix. However, if more than six character are used, problems may arise because the FORTRAN compiler truncates member names to six characters, then adds two of its own to produce CSECT and PSECT names.

ACQUIRING SFTRAN

The SFTRAN precompiler object program, the task-management PROCDEF's, documentation, instructions, and some DEFAULT values suitable for the SFTRAN environment are all contained in a partitioned data set named SFTRAN.LIB. On the Lewis Research Center's IBM 360/67 system, this data set is owned by SYSUTY and read-only access has been permitted all users.

To acquire SFTRAN capability, the user should issue the commands

```
SHARE SFTRAN,SYSUTY,SFTRAN.LIB
PROCIPAN SFTRAN(0),GOTCHA
GOTCHA
```

The result will be that USERLIB, the data set that controls the user's operating environment, will have added to its PROCDEF library the JOB command and also will have PROFILEd in its DEFAULT table a value for SFTRANID, the version number of the SFTRAN precompiler in effect at the time. (The user may wish to acquire SFTRAN immediately after LOGON so as to avoid having other, undesired default values profiled.)

Other things happen, too, when GOTCHA is executed. If USERLIB contains any PROCDEF's with the same name as one of the SFTRAN task-management PROCDEF's, these are excised. A batch printing of this USER'S GUIDE is ordered unless PRINTDOC=N is specified when the GOTCHA command is issued. Then, the entry

SFTRAN is deleted from the user's data set catalog and the PROCDEF GOTCHA is excised from USERLIB.

A brief runstream with a simple SFTRAN program is provided in appendix B to help new users get started. Listings of a larger SFTRAN program are provided in appendix C to illustrate good use of the language features.

PROCDEF's

All of the PROCDEF's for the SFTRAN command procedures, except PROCDEF JOB, are contained in member SYSPRO of SFTRAN.LIB, owned by SYSUTY. PROCDEF GOTCHA is also located there. A printer listing of the PROCDEF's may be obtained by doing

```
SHARE SFTRAN,SYSUTY,SFTRAN.LIB
DDEF PROCDEFS,VI,PROCDEFS
CDS SFTRAN(SYSPRO),PROCDEFS; DELETE SFTRAN
PRINT PROCDEFS,ERASE=Y
```

When a user acquires SFTRAN capability, execution of the command procedure GOTCHA adds PROCDEF JOB in the user's USERLIB. This is the only SFTRAN procedure definition that the user owns. He may wish to do some personal tailoring of his SFTRAN environment by altering or adding to PROCDEF JOB. For example, he may wish to change the file-naming conventions assumed in PROCDEF JOB.

In PROCDEF JOB, a LIBDEF command gives the user access to the SFTRAN pre-compiler without requiring an entry for SFTRAN.LIB in the user's catalog and with-out having a new program library added at the top of the JOBLIB stack. The PUSHPRO and MERGEPRO commands add to the user's profile environment all of the other SFTRAN task-management commands and provide default values appropriate to the SFTRAN environment should they not be found in the user's USERLIB. When the JOB command is issued without a parameter name, POPPRO commands cause the user's profile to revert back to what it was immediately before the first issuance of the JOB command.

The user's default value for SFTRANID is checked each time the precompiler is loaded by the JOB command. If the default value and the current-precompiler value do not match, the user is notified immediately that a change has been made in the system.

SFTRAN PRECOMPILER

The precompiler translates SFTRAN source code to FORTRAN source code. It was written in SFTRAN and consists of a main program, a BLOCK DATA subprogram, and seven other subprograms (excluding system-supplied routines). Communication between these is partly by calling arguments and partly by the two common blocks SFTSET and SFTCOM.

Precompiler Main Program

All parameters that control the operation of the precompiler are contained in the common block SFTSET. These are set at the start of each precompilation by the command procedure SFTRAN. (On TSS/360 these quantities are set directly by the program control system (PCS).)

Statement analysis and translation are performed in two passes in the main program. In pass 1, SFTRAN statements in the user's program are recognized and translated to FORTRAN statements. The precompiler is transparent to non-SFTRAN statements and these pass through without change. If errors are detected, they are reported along with the offending SFTRAN statement. Syntax errors are rarely fatal; pass 1 is nearly always completed. An indented listing of the user's SFTRAN program is also produced in pass 1.

A feature of SFTRAN is the use of descriptive names to refer to a block of statements. At the conclusion of pass 1, a check is made to see that the name of each PROCEDURE block was used at least once in a DO-PROCEDURE statement, and conversely. Also, a check is made to see that the name of each DEFINITION block was used in an INCLUDE statement, and conversely. Then, if no errors have been detected up to this point, pass 2 begins.

Pass 2 operates on the translated, all-FORTRAN output from pass 1. Two files are read by pass 2: one contains the bulk of the pass 1 translation, and the other contains those statements that came from DEFINITION blocks in the user's SFTRAN program. In pass 2, these two files are remerged; INCLUDE statements (which are <u>not</u> translated in pass 1) are replaced by those statements that came from the DEFINITION block of the same name. Another function of pass 2 is to append a list of statement numbers to the ASSIGNED GOTO statements generated in pass 1 at the end of each PROCEDURE block.

Precompiler Subprograms

INOUT. - All statement input and output occurs in subroutine INOUT, which has four entry points. Entry point INPUT is for input of both SFTRAN and FORTRAN statements. Output of SFTRAN statements is by entry point SFOUT; output of FORTRAN statements is by entry point F4OUT; output of error statements is by entry point ERROUT. Statement line numbers, concatenation of input lines in the case of multiline statements, and hyphenation and generation of continuation lines on output are taken care of in INOUT. In this way, system-dependent details are confined to one subprogram.

SCAN. - The statement scanning functions FIND and LOCATE are done in logical-function subprogram SCAN. FIND tests whether or not a given string next occurs in the current statement. LOCATE searches the current statement, starting with the current character, for a specified character. SCAN is also an entry point name; this entry causes scanning to begin (or resume) at a particular byte (card column) of the current statement.

An important part of SCAN is a test to see if there are any more nonblank characters in the current statement beyond the current string. This test is performed at each call to SCAN and whenever a successful call to FIND or LOCATE occurs. If more characters are found, the position and value of the first one are obtained; if only blank characters (spaces) remain, these are eliminated by a reduction of the statement-length count.

NCODE and DCODE. - Subprograms NCODE and DCODE convert internal integer numbers to digit strings, and conversely. When a character string is decoded, the value of logical function DCODE is .FALSE. if any decoding errors were encountered. (One of the uses of DCODE is to determine whether or not a string of characters represents a literal integer constant.)

ERROR. - Subroutine ERROR has two entry points; ERROR, for nonfatal error messages, and HALT, for fatal error messages. In this subroutine, the error message is received in the argument string as a parenthetical expression. These parentheses are located and the error message is extracted and appended to *ERROR*, or *FATAL ERROR*, as the case may be. This complete message is then announced, together with the current SFTRAN statement responsible for the message, by calls to ERROUT.

PARENS. - Logical-function subprogram PARENS scans a string to see if a complete parenthetical expression begins at a specified byte (or is preceded by only blank characters). If left and right parentheses are found, their byte positions are returned.

ADDBUF. - Subroutine ADDBUF adds a string of characters to the output buffer used for generating FORTRAN statements and increments the count of the total number of characters in the buffer.

Character-Manipulating Routines

Three character-manipulating subprograms, which are not part of the FORTRAN library, are used in the SFTRAN precompiler. These are system-supplied, assembler-language routines that give SFTRAN and FORTRAN programs access to the powerful IBM 360/67 machine instructions MVC (move characters), CLC (compare logical characters), and TRT (translate and test). These subroutines are contained in the system-supplied module CHCF4C.

F4MVC(A,I,B,J,N). - Subroutine F4MVC moves N characters from string A to string B, starting with the Ith character of A, which replaces the Jth character of B. (I, J, and N must all be greater than zero.)

F4CLC(A,I,B,J,N). - Logical-function subprogram F4CLC compares N characters of string A with N characters of string B, starting with the Ith character of A, which is compared to the Jth character of B, etc.(I, J, and N must all be greater than zero.) A .TRUE. value is returned only when a match is obtained for all N characters.

F4TRT(A,I,J,T,K,C,L). - Logical-function subprogram F4TRT tests and translates characters from string A, using translation table T. Processing starts with the Ith character of A and ends with completion of the Jth character of A or when a translation for the current character is found in the table. A .TRUE. value is returned if a translation is found. In that case, the index of the translated character is returned in K, the character resulting from the translation is returned in C (as a 1-byte variable), and its number value is returned in L (as an integer). The F4TRT function is used only in subprogram SCAN and there only for locating the next nonblank character in the current statement. For this purpose, the translation table consists of the complete character set, less the space character (hexadecimal 40), with no change of character codes.

Lewis Research Center,

National Aeronautics and Space Administration,

Cleveland, Ohio, July 27, 1977,

505-01.

APPENDIX A

SUMMARY OF TASK-MANAGEMENT COMMANDS

In summarizing the task-management commands, notation similar to that of reference 1 is used: command names, keywords, and formal operands are in upper case and functional operands are in lower case. Also, several metasymbols are used:

[ ]	delimits optional operand fields
{ }	delimits operand alternatives
|	separates operand alternatives
. . .	indicates that the preceding field may be repeated (up to 9 times)

```
Command           Operands

EDITLIB           member name

ERASELIB          member name [,...]

FORTRAN           member name [,...]
                  [,LISTING={Y|N}] [,LINES={Y|N}]

JOB               [{job name|?}]
                  [,FORTRAN={Y|N}] [,LISTING={Y|N}] [,LINES={Y|N}]
                  [,NUMBER={Y|N}] [,STRIP={Y|N}] [,OFFLINE={Y|N}]

LISTINGS          member name [,...]
                  [,LINES={Y|N}]

PRINTLIB          member name [,...]
                  [,LINES={Y|N}]

REDITLIB          member name [,$OPTIONS='REDIT command string']

SFTRAN            member name [,...]
                  [,FORTRAN={Y|N}] [,LISTING={Y|N}] [,LINES={Y|N}]
                  [,NUMBER={Y|N}] [,STRIP={Y|N}] [,OFFLINE={Y|N}]
                  [,$SFTRECL=source-code line length]

STORE             member name [,...]
                  [,ERASE={Y|N}]
```

```
UNSTORE         member name [,...]
²$INCLUDE       member name [,...]
²$STAME         member name
```

[2]These commands are not intended for direct user use.

APPENDIX B

SAMPLE RUNSTREAM

The following runstream is an example of how the SFTRAN system is used at a terminal. The usual LOGON procedure and the procedure described previously for acquiring SFTRAN are assumed to have already been completed. User-entered lines are displayed in lower case and system responses are displayed in upper case.

```
job learn
reditlib try1
LOADING SOURCE.LEARN(TRY1)
NEW DATA SET--DEFAULT FILE NAME SET
input
INPUT
c.....this is my first try at sftran programming.
      include (preliminaries)
c
      do with
      read (5,1,done=end) string
      until (done .or. string(1).eq.blank)
      write (6,2) string
      end
      stop
c
  1   format (10a4)
  2   format ('  you said: ',10a4)
      definition (preliminaries)
      logical done
      dimension string(10)
      data blank /' '/
      end
      end

EDIT
file
EDIT
pause
TO CONTINUE EDITING TYPE: CONEDIT
sftran try1
CHCRW400      TERMINATED: STOP
call try1$
123456
 YOU SAID: 123456
abc ... xyz
 YOU SAID: ABC ... XYZ
```

```
CHCRW400     TERMINATED: STOP
listings try1
E033         PRINT BSN=1759,      100 LINES
```

The indented listing of SFTRAN code produced by the last user command is as follows:

```
          SOURCE.LEARN(TRY1)    03/15/77 13:54:52   SFTRAN, VERSION 3

C.....THIS IS MY FIRST TRY AT SFTRAN PROGRAMMING.
      INCLUDE (PRELIMINARIES)
C
      DO WITH
         READ (5,1,DONE=END) STRING
      UNTIL (DONE .OR. STRING(1).EQ.BLANK)
         WRITE (6,2) STRING
      END
      STOP
C
  1   FORMAT (10A4)
  2   FORMAT ('  YOU SAID: ',10A4)
      DEFINITION (PRELIMINARIES)
         LOGICAL DONE
         DIMENSION STRING(10)
         DATA BLANK /'  '/
      END
      END
```

APPENDIX C

SFTRAN EXAMPLES

The following listings are intended to illustrate the use of SFTRAN coding. The first example is an indented SFTRAN program listing as produced by LISTINGS. It contains all of the SFTRAN structures currently available and is in good "top-down" form. Next is a portion of the same demonstration program as it would appear when NUMBER=Y is specified. The last example is the FORTRAN code generated by the precompiler at the same time it produced the numbered SFTRAN listing.

The numbered examples were produced with LINES=Y to illustrate the correspondence between SFTRAN output and FORTRAN output numbering. Not shown is the degree to which these correspond to the <u>input</u> data-set numbering. The general rule can be stated quite simply: the SFTRAN precompiler makes every effort to give output lines the same index numbers as input lines; when additional output lines must be generated, their numbers are incremented by 1 (cf. lines 10800-10804 of the example FORTRAN listing). The result is that, although generally the programmer does not see his line numbers, if an error message refers to some specific line number, he knows exactly where (in the input data set) it can be found.

One exception to the rule just mentioned is found in lines that have been moved as a result of the use of INCLUDE-DEFINITION statements. The starting line number of a moved block of statements will be the line number of the INCLUDE statement they replace.

```
          SOURCE.SPTRAN(DEMO)    03/14/77 22:12:00  SPTRAN, VERSION 3

C.....PROGRAM TO DEMONSTRATE SPTRAN CODING.

C     THIS PROGRAM CALCULATES MOLECULAR WEIGHT FOR A
C     GIVEN MOLECULAR FORMULA.

      INCLUDE (TYPE AND DATA STATEMENTS)


C.....MAIN FLOW:

      DO WITH
         DO (INITIALIZE FOR NEW FORMULA)
         READ (1,100,DONE=END) FORMLA
      UNTIL (DONE)
         DO UNTIL (ERROR .OR. TYPE.EQ.0)
            DO (IDENTIFY NEXT BYTE TO DETERMINE PROCESSING TYPE)
            DO CASE (TYPE,3)
            CASE 1
               DO (PROCESS NEW ELEMENT)
            CASE 2
               DO (BEGIN NEW RADICAL)
            CASE 3
               DO (END CURRENT RADICAL)
            END
         END
         IF (.NOT.ERROR) THEN
            IF (LEVEL.EQ.0) THEN
               WRITE (2,200) MOLWT
            ELSE
               WRITE (2,201)
            END
         END
      END
      STOP


C.....MAIN PROCEDURES:

      PROCEDURE (IDENTIFY NEXT BYTE TO DETERMINE PROCESSING TYPE)
         DO (GET NEXT BYTE FROM FORMULA)
         TYPE=1
         IF (BYTE.EQ.LPAREN)  TYPE=2
         IF (BYTE.EQ.RPAREN)  TYPE=3
         IF (BYTE.EQ.SPACE)  TYPE=0
         NEXT=NEXT+1
      END

      PROCEDURE (PROCESS NEW ELEMENT)
         DO (ASSEMBLE ELEMENT SYMBOL)
         DO (FIND MATCHING ELEMENT IN TABLE)
         IF (FOUND) THEN
            DO (READ NUMBER OF ATOMS/RADICALS)
          IF (LEVEL.EQ.0) THEN
             MOLWT=MOLWT+FLOAT(N)*ATWT(ATNO)
          ELSE
             RADWT(LEVEL)=RADWT(LEVEL)+FLOAT(N)*ATWT(ATNO)
          END
       END
    END

    PROCEDURE (BEGIN NEW RADICAL)
       LEVEL=LEVEL+1
       IF (LEVEL.GT.LMAX) THEN
          ERROR=.TRUE.
          WRITE (2,202)
       ELSE
          RADWT(LEVEL)=0.0
       END
    END

    PROCEDURE (END CURRENT RADICAL)
       LEVEL=LEVEL-1
       IF (LEVEL.GE.0) THEN
          DO (READ NUMBER OF ATOMS/RADICALS)
          IF (LEVEL.GT.0) THEN
             RADWT(LEVEL)=RADWT(LEVEL)+FLOAT(N)*RADWT(LEVEL+1)
          ELSE
             MOLWT=MOLWT+FLOAT(N)*RADWT(1)
          END
       ELSE
          ERROR=.TRUE.
          WRITE (2,203)
       END
    END


C.....MORE DETAILS:

    PROCEDURE (INITIALIZE FOR NEW FORMULA)
       MOLWT=0.0
       LEVEL=0
       NEXT=1
       ERROR=.FALSE.
    END

    PROCEDURE (ASSEMBLE ELEMENT SYMBOL)
       DO (PUT FIRST BYTE INTO SYMBOL)
       DO (GET NEXT BYTE FROM FORMULA)
       IF (BYTE.GE.SMALLA .AND. BYTE.LE.SMALLZ) THEN
          NEXT=NEXT+1
       ELSE
          BYTE=SPACE
       END
       DO (PUT SECOND BYTE INTO SYMBOL)
```

```
      END

      PROCEDURE (FIND MATCHING ELEMENT IN TABLE)
         DO FOR ATNO=1,NELEMS
            FOUND=SYMBOL.EQ.ELEMNT(ATNO)
         <--IF (FOUND) EXIT (ATNO)
         OTHERWISE
            ERROR=.TRUE.
            WRITE (2,204) SYMBOL
         END
      END

      PROCEDURE (READ NUMBER OF ATOMS/RADICALS)
         N=0
         DO WITH
            DO (GET NEXT BYTE FROM FORMULA)
         WHILE (BYTE.GE.ZERO .AND. BYTE.LE.NINE)
            N=10*N+(BYTE-ZERO)
            NEXT=NEXT+1
         END
         N=MAX0(N,1)
      END

C.....NOTE -- F4MVC (A,I,B,J,N) IS AN EXTERNAL SUBROUTINE WHICH MOVES
C             N CHARACTERS FROM STRING A TO STRING B, STARTING WITH
C             THE I-TH BYTE OF A WHICH REPLACES THE J-TH BYTE OF B.

      PROCEDURE (GET NEXT BYTE FROM FORMULA)
         CALL F4MVC (FORMLA,NEXT,BYTE,4,1)
      END

      PROCEDURE (PUT FIRST BYTE INTO SYMBOL)
         CALL F4MVC (BYTE,4,SYMBOL,1,1)
      END

      PROCEDURE (PUT SECOND BYTE INTO SYMBOL)
         CALL F4MVC (BYTE,4,SYMBOL,2,1)
      END


C.....MISCELLANEOUS.

100   FORMAT (19A4,A1)
200   FORMAT (' MOLECULAR WEIGHT =',F10.3)
201   FORMAT (' ERROR: PARENTHESES DO NOT MATCH')
202   FORMAT (' ERROR: TOO MANY NESTED RADICALS')
203   FORMAT (' ERROR: TOO MANY RIGHT PARENTHESES')
204   FORMAT (' ERROR: UNKNOWN ELEMENT = ',A2)

      DEFINITION (TYPE AND DATA STATEMENTS)
         IMPLICIT INTEGER (A-Z)
         REAL ATWT,MOLWT,RADWT
```

```
    SOURCE.SPTRAN(DEMO)    03/14/77 22:12:00  SPTRAN, VERSION 3

    LOGICAL DONE,ERROR,FOUND
    DIMENSION ATWT(110),ELEMNT(110),FORMLA(20),RADWT(10)

    DATA SPACE,LPAREN,RPAREN,SMALLA,SMALLZ,ZERO,NINE
*        /  64,    77,    93,   129,    169, 240, 249/

    DATA LMAX,NELEMS,FORMLA,SYMBOL/10,20,21*' '/

    DATA ELEMNT(1),  ATWT(1)  / 'H',     1.00797 /,
*        ELEMNT(2),  ATWT(2)  / 'He',    4.0026  /,
*        ELEMNT(3),  ATWT(3)  / 'Li',    6.939   /,
*        ELEMNT(4),  ATWT(4)  / 'Be',    9.0122  /,
*        ELEMNT(5),  ATWT(5)  / 'B',    10.811   /,
*        ELEMNT(6),  ATWT(6)  / 'C',    12.01115 /,
*        ELEMNT(7),  ATWT(7)  / 'N',    14.0067  /,
*        ELEMNT(8),  ATWT(8)  / 'O',    15.9994  /,
*        ELEMNT(9),  ATWT(9)  / 'F',    18.9984  /,
*        ELEMNT(10), ATWT(10) / 'Ne',   20.183   /
    DATA ELEMNT(11), ATWT(11) / 'Na',   22.9898  /,
*        ELEMNT(12), ATWT(12) / 'Mg',   24.312   /,
*        ELEMNT(13), ATWT(13) / 'Al',   26.9815  /,
*        ELEMNT(14), ATWT(14) / 'Si',   28.086   /,
*        ELEMNT(15), ATWT(15) / 'P',    30.9738  /,
*        ELEMNT(16), ATWT(16) / 'S',    32.064   /,
*        ELEMNT(17), ATWT(17) / 'Cl',   35.453   /,
*        ELEMNT(18), ATWT(18) / 'Ar',   39.948   /,
*        ELEMNT(19), ATWT(19) / 'K',    39.102   /,
*        ELEMNT(20), ATWT(20) / 'Ca',   40.08    /
 END

 END
```

A part of SFTRAN listing of DEMO produced with NUMBER=Y is as follows:

```
0008700 C.....MORE DETAILS:
0008800
0008900 30002 PROCEDURE (INITIALIZE FOR NEW FORMULA)
0009000 30002    MOLWT=0.0
0009100          LEVEL=0
0009200          NEXT=1
0009300          ERROR=.FALSE.
0009400 10008 END
0009500
0009600 30008 PROCEDURE (ASSEMBLE ELEMENT SYMBOL)
0009700 30008    DO (PUT FIRST BYTE INTO SYMBOL)
0009800 20037    DO (GET NEXT BYTE FROM FORMULA)
0009900 20038    IF (BYTE.GE.SMALLA .AND. BYTE.LE.SMALLZ) THEN
0010000             NEXT=NEXT+1
0010100 20039    ELSE
0010200 20039       BYTE=SPACE
0010300 20040    END
0010400 20040    DO (PUT SECOND BYTE INTO SYMBOL)
0010500 20041 END
0010600
0010700 30009 PROCEDURE (FIND MATCHING ELEMENT IN TABLE)
0010800 30009    DO FOR ATNO=1,NELEMS
0010900 20043       FOUND=SYMBOL.EQ.ELEMNT(ATNO)
0011000 10009    <--IF (FOUND) EXIT (ATNO)
0011100 20044    OTHERWISE
0011200 20044       ERROR=.TRUE.
0011300             WRITE (2,204) SYMBOL
0011400 20042    END
0011500 20045 END
0011600
0011700 30010 PROCEDURE (READ NUMBER OF ATOMS/RADICALS)
0011800 30010    N=0
0011900 20046    DO WITH
0012000 20046       DO (GET NEXT BYTE FROM FORMULA)
0012100 20048    WHILE (BYTE.GE.ZERO .AND. BYTE.LE.NINE)
0012200             N=10*N+(BYTE-ZERO)
0012300             NEXT=NEXT+1
0012400 10010    END
0012500 20047    N=MAX0(N,1)
0012600 10011 END
```

A part of the FORTRAN code produced from DEMO with NUMBER=Y is as follows:

```
C.....MORE DETAILS:

C     PROCEDURE (INITIALIZE FOR NEW FORMULA)
30002 MOLWT=0.0
      LEVEL=0
      NEXT=1
      ERROR=.FALSE.
10008 GO TO NPR002, (20003)

C     PROCEDURE (ASSEMBLE ELEMENT SYMBOL)
30008 ASSIGN 20037 TO NPR011
      GO TO 30011
20037 ASSIGN 20038 TO NPR007
      GO TO 30007
20038 IF (.NOT.(BYTE.GE.SMALLA .AND. BYTE.LE.SMALLZ)) GO TO 2003
      NEXT=NEXT+1
      GO TO 20040
20039 BYTE=SPACE
20040 ASSIGN 20041 TO NPR012
      GO TO 30012
20041 GO TO NPR008, (20023)

C     PROCEDURE (FIND MATCHING ELEMENT IN TABLE)
30009 ATNO=1
      N20042=NELEMS
      GO TO 20043
20042 ATNO=ATNO+1
      IF ((N20042-ATNO).LT.0) GO TO 20044
20043 FOUND=SYMBOL.EQ.ELEMNT(ATNO)
10009 IF (FOUND) GO TO 20045
      GO TO 20042
20044 ERROR=.TRUE.
      WRITE (2,204) SYMBOL
20045 GO TO NPR009, (20024)

C     PROCEDURE (READ NUMBER OF ATOMS/RADICALS)
30010 N=0
20046 ASSIGN 20048 TO NPR007
      GO TO 30007
20048 IF (.NOT.(BYTE.GE.ZERO .AND. BYTE.LE.NINE)) GO TO 20047
      N=10*N+(BYTE-ZERO)
      NEXT=NEXT+1
10010 GO TO 20046
20047 N=MAX0(N,1)
10011 GO TO NPR010, (20027,20034)
```

REFERENCE

1. IBM Time Sharing System Command System User's Guide. IBM Corp. Reference Manual GC28-2001, 10th ed., Aug. 1976.

1. Report No. NASA TP-1006	2. Government Accession No.	3. Recipient's Catalog No.
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16. Abstract

Extensions and improvements have been made to SFTRAN, a structured-programming language. This improved language has been implemented as a precompiler that translates from SFTRAN to FORTRAN and has been available to users of the Lewis Research Center's IBM 360/67 Time-Sharing System for the past year. This report describes the SFTRAN language and its use. Time-Sharing System (TSS) command procedures have been implemented that eliminate the complications of dealing with extra files and processing steps which the use of a precompiler would otherwise require. These command procedures are described and their use is illustrated by examples.

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